Executive Summary: Forecasting Emergency Road Service Demand for AAA Washington

This project was conducted to support **AAA Washington** in forecasting monthly emergency road service (ERS) call volumes. The organization sought to improve its budgeting and resource planning by predicting demand more accurately using historical data and environmental indicators.

The analysis was structured in three phases:

Phase 1: Exploratory Time Series Analysis

Initial visualization of call volume data from **May 1988 to August 1992** revealed strong **seasonality**, with lower call volumes during warmer months and higher demand during colder months. A moderate **upward trend** and some autocorrelation patterns were also observed. Based on these insights, we applied time series decomposition to confirm the seasonal and irregular components.

Phase 2: Box-Jenkins Modeling (SARIMA)

To capture temporal dependencies and seasonality more rigorously, several **Seasonal ARIMA (SARIMA)** models were tested. Six candidate models were evaluated using training and validation splits. The model that performed best was:

$$\text{SARIMA}(1,0,0) \times (1,1,0)_{12}$$

This model achieved a **MAPE of 2.51%** on validation data and showed **minimal error variance and strong robustness**, outperforming all other alternatives. Residual diagnostics confirmed independence and stationarity, although one outlier and slight non-normality were noted.

Phase 3: Time Series Regression with Exogenous Variables

To further enhance accuracy, we incorporated **average monthly temperature** and **Washington State unemployment rate** as external predictors. A transformed temperature variable, measuring **deviation from the optimal 60°F**, showed a strong positive linear relationship with ERS call volume. Cross-correlation analysis indicated that unemployment rates **lead service call volume by 11 months**, making them a viable economic indicator.

A multiple regression model including the temperature deviation and a **11-month lagged unemployment rate** achieved a **MAPE of 3.58%** on validation data.

This model explained a meaningful portion of the variability in calls about 57%, though residual analysis revealed some autocorrelation, suggesting potential benefit from integrating ARIMA components in future iterations.

Recommendation

Based on model performance and interpretability, we recommend **using the SARIMA(1,0,0)(1,1,0)$_{12}$** model for short- to medium-term forecasting. For enhanced insight and longer-term forecasting, the regression model combining **temperature deviation** and **lagged unemployment rate** is also valuable.

To support operations planning, the **forecasted ERS call volume for January 1994** using the SARIMA model is **22,585 calls**. This forecast has an expected error margin of approximately ±2.51%.

We advise AAA Washington to update and retrain these models quarterly, and consider adding other weather or traffic-related predictors to further improve forecasting precision.